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10ME/AU/PM33

Third Semester B.E. Degree Examination, December 2012
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Use of thermodynamic data handbook and steam tables is permitted.

PART – A

1 a. Define the following with examples:
i) Open system ii) Closed system iii) Path function iv) Point function. **(08 Marks)**

b. Distinguish between:
i) Intensive and extensive properties
ii) Thermal equilibrium and mechanical equilibrium
iii) Microscopic and macroscopic point of view. **(06 Marks)**

c. State zeroth law of thermodynamics. The temperature, t, on a certain scale is defined in terms of the thermometric property X by the relation $t = a \ln \chi + b$ where a and b are constants. On this scale the temperature of ice and steam points are 0 and 100, respectively. Experiments reveal that $X_i = 1.86$ and $X_s = 6.81$. Find the temperature for an X value of 3.2 on this thermometer. **(06 Marks)**

2 a. List the similarities between heat and work. **(04 Marks)**

b. State and explain thermodynamic definition of work. **(04 Marks)**

c. Derive the expression for the displacement work in resisted polytropic process. (PV^n = Constant). **(06 Marks)**

d. A certain mass of air is compressed from 1 bar, 0.1 m^3 to 6 bar in a piston cylinder device according to $PV^{1.4}$ = constant. Find the work of compression for air. Had the compression been carried out hyperbolically between the same initial state and the same final pressure as above what would be the work done on air? **(06 Marks)**

3 a. State and explain the first law of thermodynamics. Give its equation with reference to a cyclic and non-cyclic process. **(06 Marks)**

b. A fluid is confined in a cylinder by spring loaded, frictionless piston so that the pressure in the fluid is linear function of the volume (P = a + bV). The internal energy of the fluid is given by the following equation:

$$U = 34 + 3.15\ PV$$

where U is in kJ, p in kPa and V in cubic metre. If the fluid changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. **(08 Marks)**

c. Steam at a rate of 0.42 kg/s and enthalpy of 2785 kJ/kg and a velocity of 33.3 m/s is supplied to a steadily operating turbine. The steam leaves the turbine at 100 m/s and an enthalpy of 2512 kJ/kg. The inlet pipe is 3 m above the exit pipe. Rate of heat loss from the turbine casing is 0.29 kJ/s. What is the power output of the turbine? **(06 Marks)**

4 a. Why are engineers interested in reversible processes even though they can never be achieved? **(02 Marks)**

b. Define reversible engine. Show that of all the reversible heat engines working between any two constant but different thermal reservoir temperatures, the reversible reversed heat engine will have the maximum COP. **(08 Marks)**

c. A Carnot engine receives heat at 750 K and rejects the waste heat to the environment at 300K. The entire output of the heat engine is used to drive a Carnot refrigerator that removes heat from the cooled space at –15°C at a rate of 400 kJ/min and rejects to the same environment at 300K. Determine the i) the rate of heat supplied to the heat engine ii) the total rate of heat rejection to the environment. **(10 Marks)**

PART – B

5 a. Define inequality of Clausius and entropy of a system. Show that for an irreversible process $ds \geq \delta Q/T$. **(10 Marks)**

b. 1.5 kg of air initially at 25°C is heated reversibly at constant pressure until volume is doubled and heated reversibly until pressure is doubled at constant volume. For the total path, determine i) the work transfer ii) the heat transfer and iii) the change in entropy. **(10 Marks)**

6 a. Sketch the T-P phase diagram for water. Mark on it the following: Solid region, liquid region, vapour phase, triple point and critical point. **(05 Marks)**

b. State whether the following samples of steam are wet, dry or superheated. Justify your answer. i) Pressure = 1 MPa absolute, enthalpy = 2880 kJ/kg, ii) Pressure = 500 kPa absolute, Volume = $0.35 m^3/kg$ iii) Temperature = 200°C, Pressure = 1.2 MPa. iv) Temperature = 100°C , entropy = 6.88 kJ/kgK v) Pressure = 10 kPa, enthalpy = 2584.8 kJ/kg. **(05 Marks)**

c. 0.1 kg saturated steam expands reversibly from 10 to 1 bar in a piston-cylinder device according $PV^{1.3}$ = constant. Find the work and heat interactions during the expansion process. **(10 Marks)**

7 a. Distinguish between i) Universal gas constant and particular gas constant ii) Perfect gas and semiperfect gas. **(08 Marks)**

b. 1 kg of air undergoes a cylic process comprising three process 1-2, 2-3 and 3-1. At state 1, the pressure and temperature are 1 MPa and 27°C. 1-2 is an irreversible adiabatic constant pressure process, 2-3 is reversible adiabatic process and 3-1 is a reversible isothermal process. At state 3, p = 100 kPa.

i) Sketch the cycle on P-V and T-S coordinates,
ii) Find the heat and work interactions in each of the three processes and the net work per cycle and
iii) Analyse quantitatively whether the cycle is reversible or irreversible. **(12 Marks)**

8 a. Explain the following:
i) Compressibility factor ii) Law of corresponding states iii) Compressibility chart iv) Van der Waals equation of state. **(12 Marks)**

b. A mixture of 0.5 kg of carbon dioxide and 0.3 kg of N_2 is compressed from P_1 = 1 atm, T_1 = 20°C to P_2 = 5 atm in a polytropic process for which n = 1.3. Find i) The final temperature ii) The work iii) The heat transfer iv) The change in entropy of the mixture. **(08 Marks)**

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